PHENIX Detector Upgrade for Triggering Fast Muons from W-Boson Decays Using RPC Technology

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For

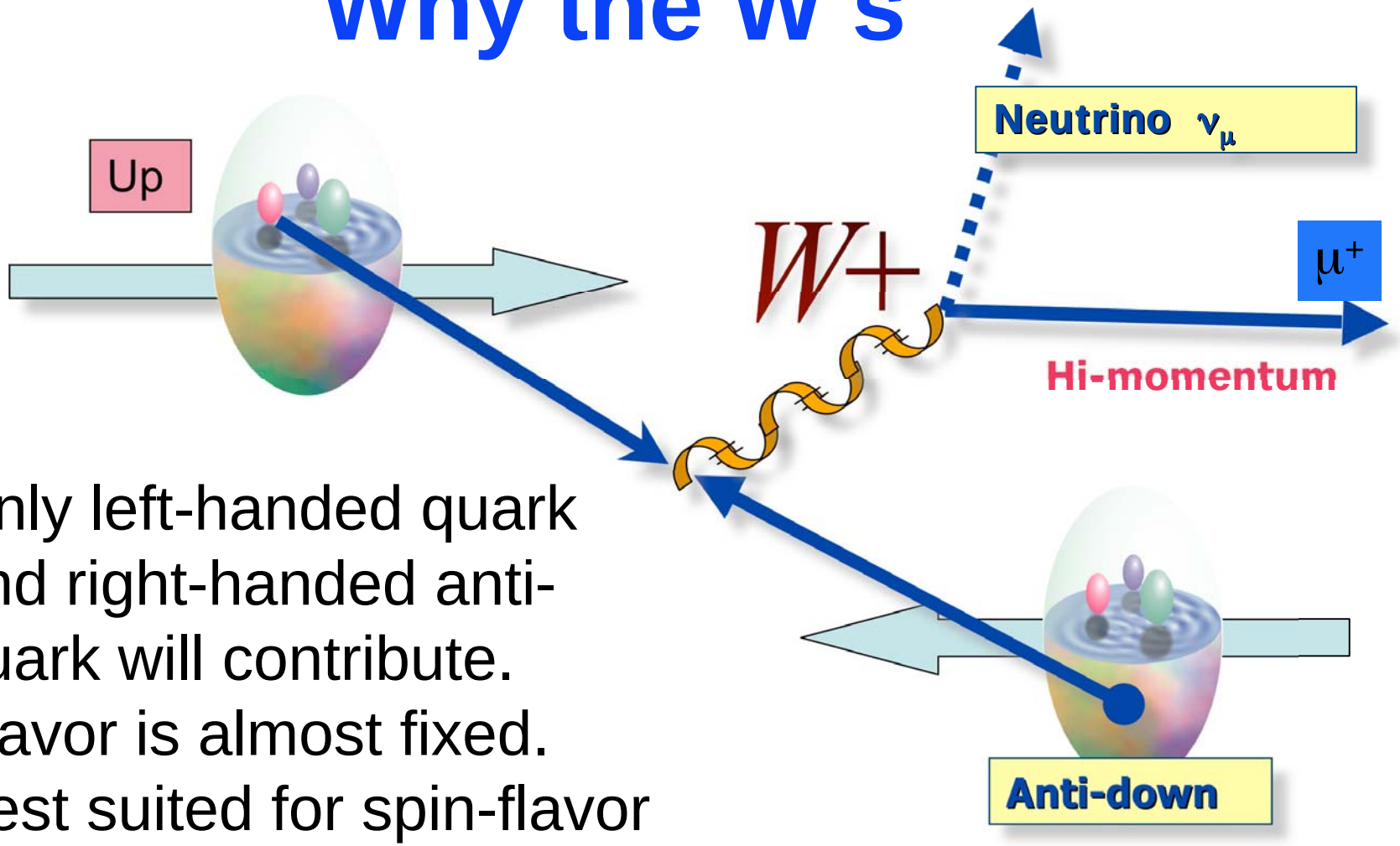
PHENIX Collaboration

PHENIX

Outline

- Physics Goal
- Forward Muon Trigger Upgrade for the PHENIX/RHIC experiment
  - Resistive Plate Chamber (RPC) Technology choice.
  - RPC Production.
  - RPC Installation.
- Current Status and Outlook

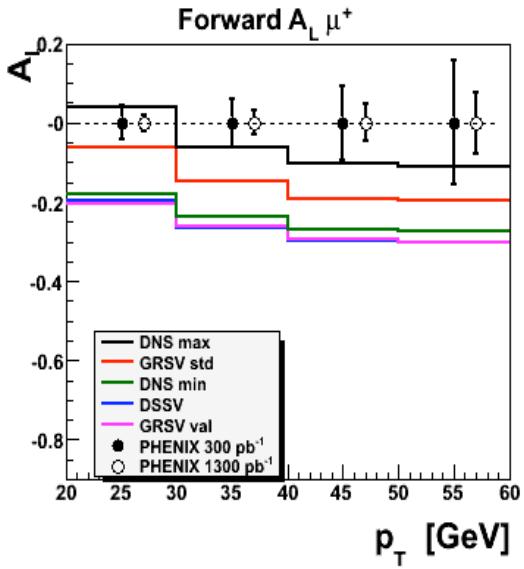
Why the W's

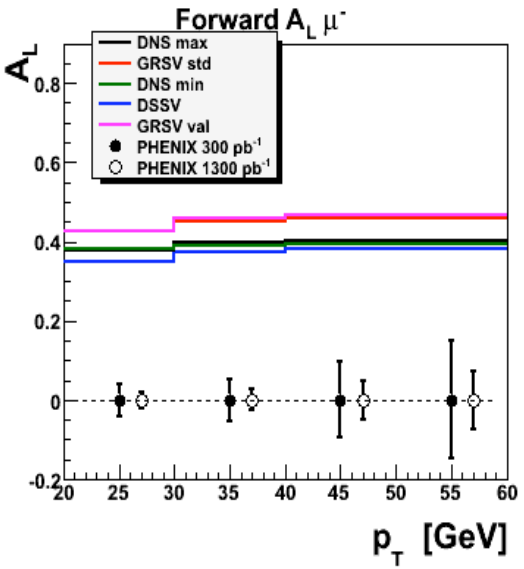


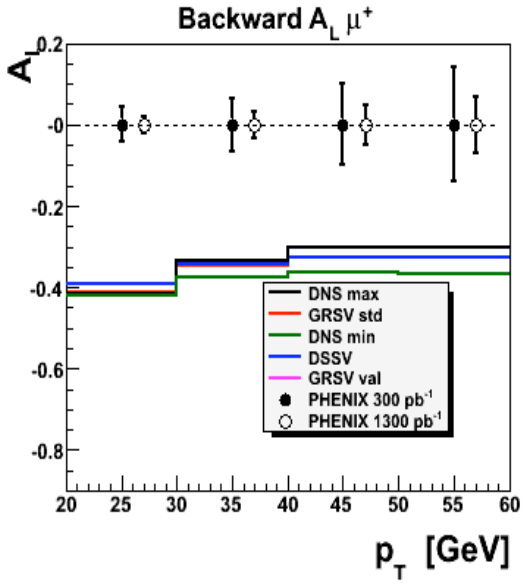
- Only left-handed quark and right-handed anti-quark will contribute.
- Flavor is almost fixed.
- Best suited for spin-flavor structure studies.

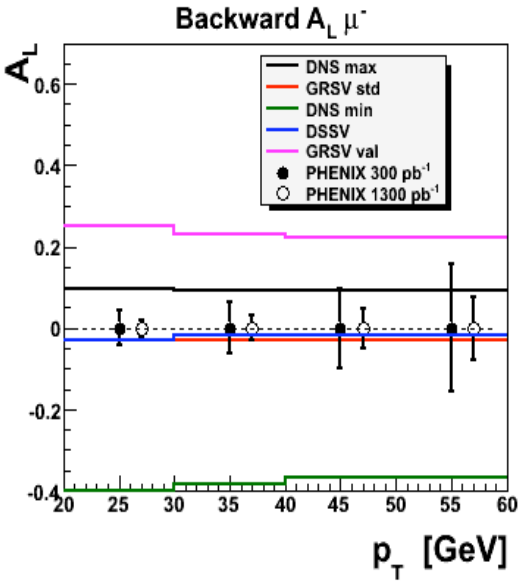
Projected Sensitivity

- Forward and Backward Asymmetries
- Momentum resolution is fully incorporated

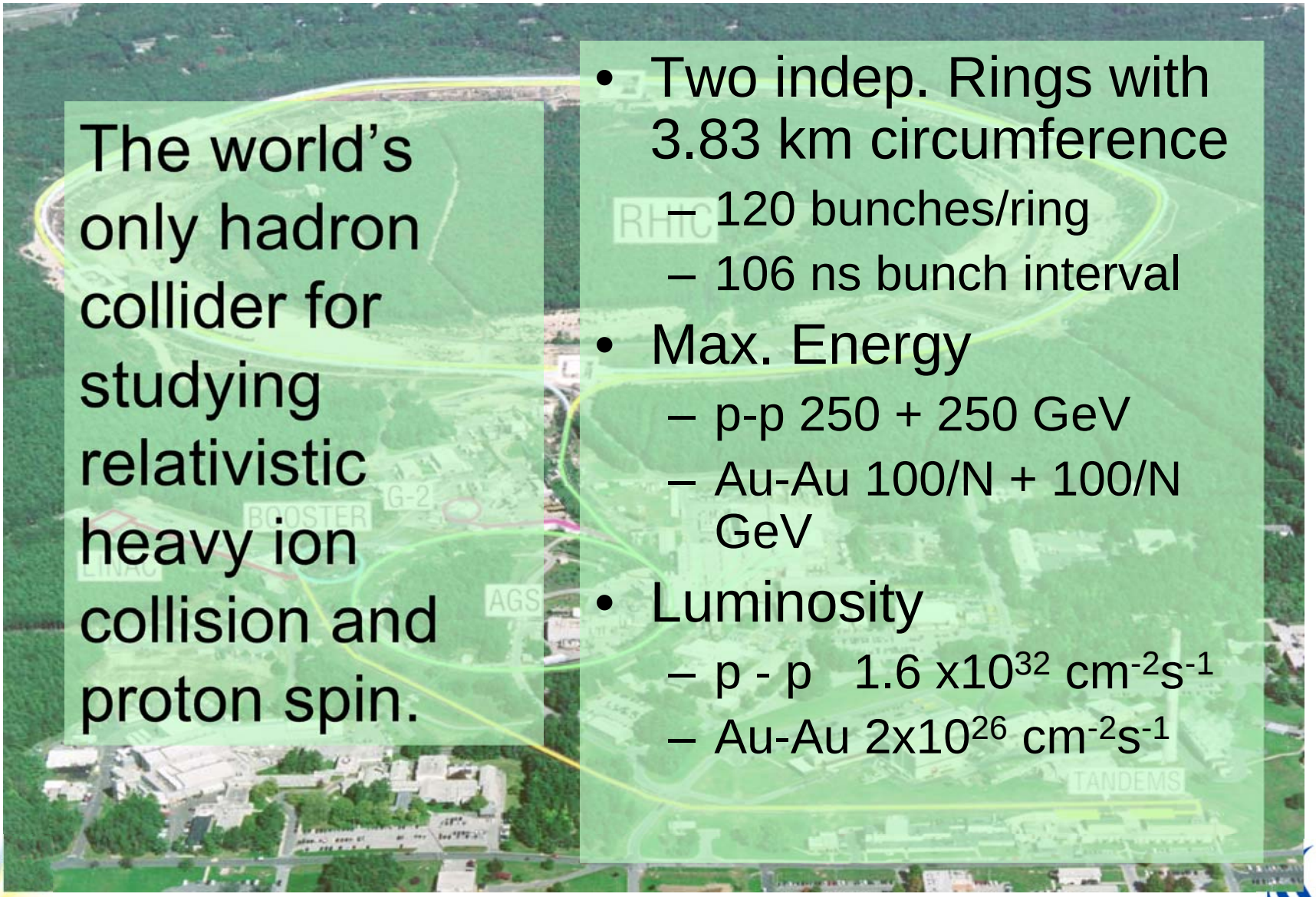








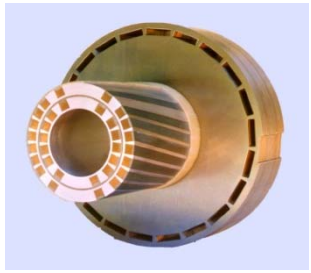
RHIC Complex



The world's only hadron collider for studying relativistic heavy ion collision and proton spin.

- Two indep. Rings with 3.83 km circumference
  - 120 bunches/ring
  - 106 ns bunch interval
- Max. Energy
  - p-p 250 + 250 GeV
  - Au-Au 100/N + 100/N GeV
- Luminosity
  - p - p 1.6 x10^{32} cm^{-2}s^{-1}
  - Au-Au 2x10^{26} cm^{-2}s^{-1}

RHIC-SPIN



Absolute Polarimeter (H jet)

RHIC pC Polarimeters

Siberian Snakes

PHENIX (p)

Spin flipper

STAR (p)

Spin Rotators
(longitudinal polarization)

Spin Rotators
(longitudinal polarization)

Solenoid Partial Siberian Snake

LINAC

BOOSTER

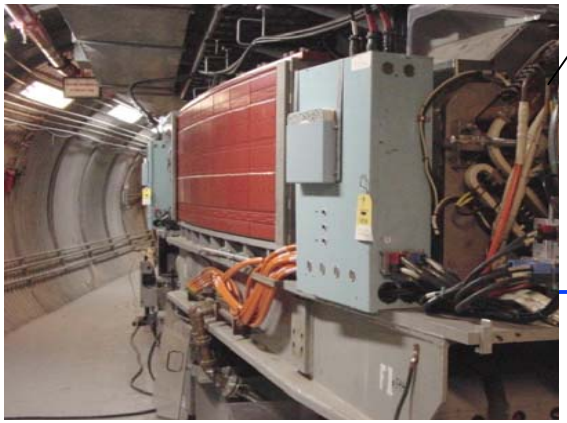
Pol. H⁻ Source

Helical Partial
Siberian Snake

AGS

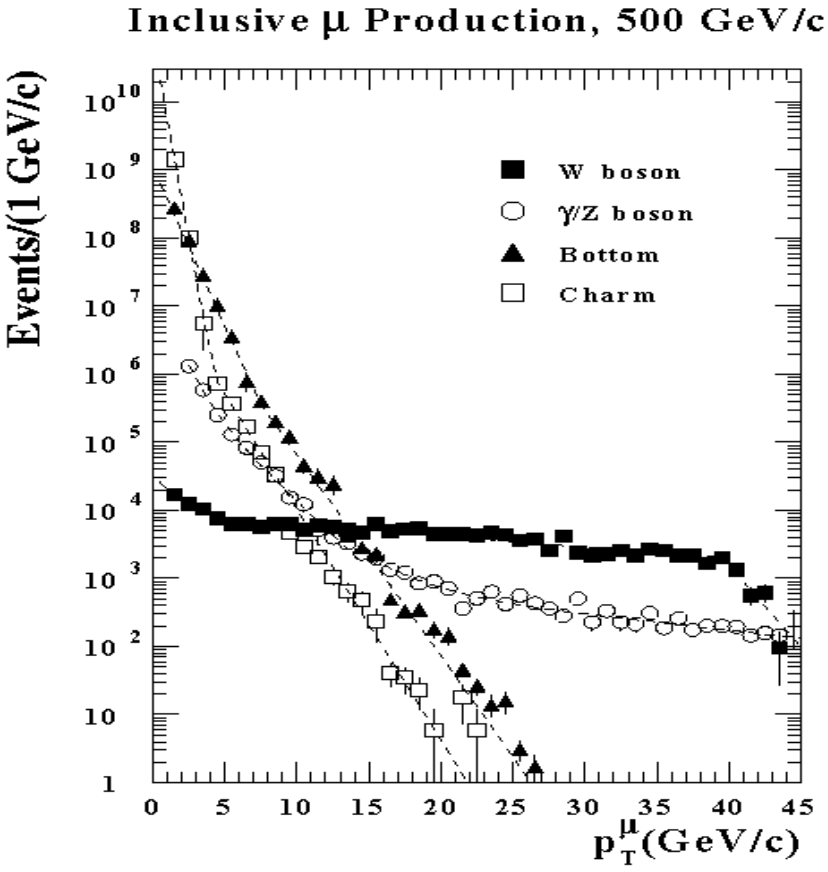
200 MeV Polarimeter

AGS Polarimeters

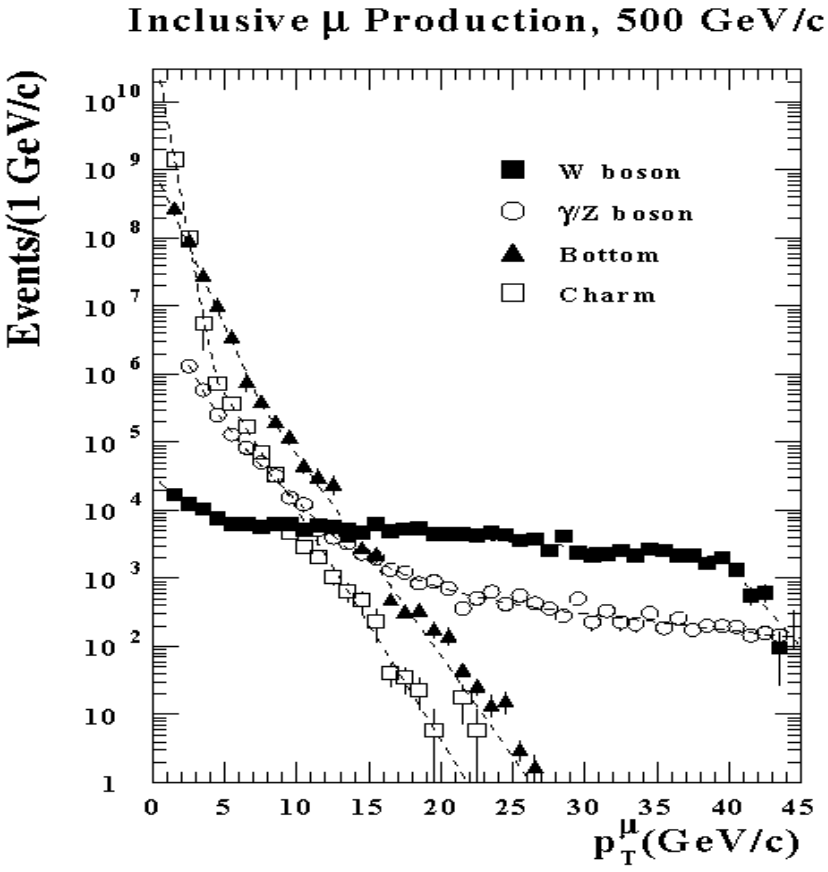


Three Challenges for W Measurement

- Huge background muons.
- Limited space within the existing PHENIX detector system.
- New detector construction and the associated costs.



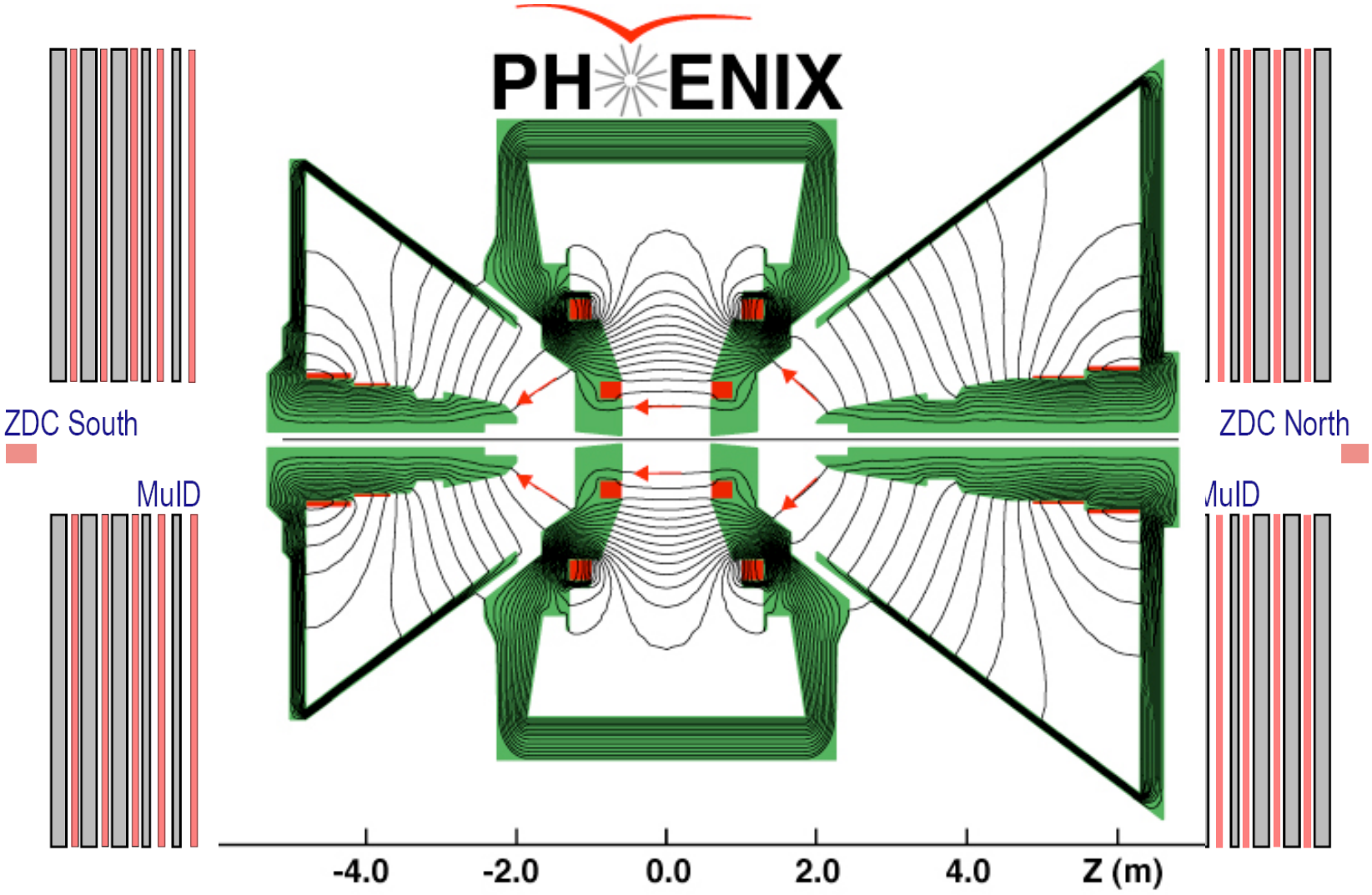
Necessity of Muon Trigger Upgrade



Pythia Simulation

- Hadronic decays dominate muon rates
- W dominate only above 20-25 GeV
- DAQ cannot take full rate @500GeV
- Current muon trigger momentum “blind”
  - ➔ Need for a momentum sensitive muon trigger
  - ➔ Add Resistive Plate Chambers(RPCs)
  - ➔ Add fast readout electronics for Muon tracker

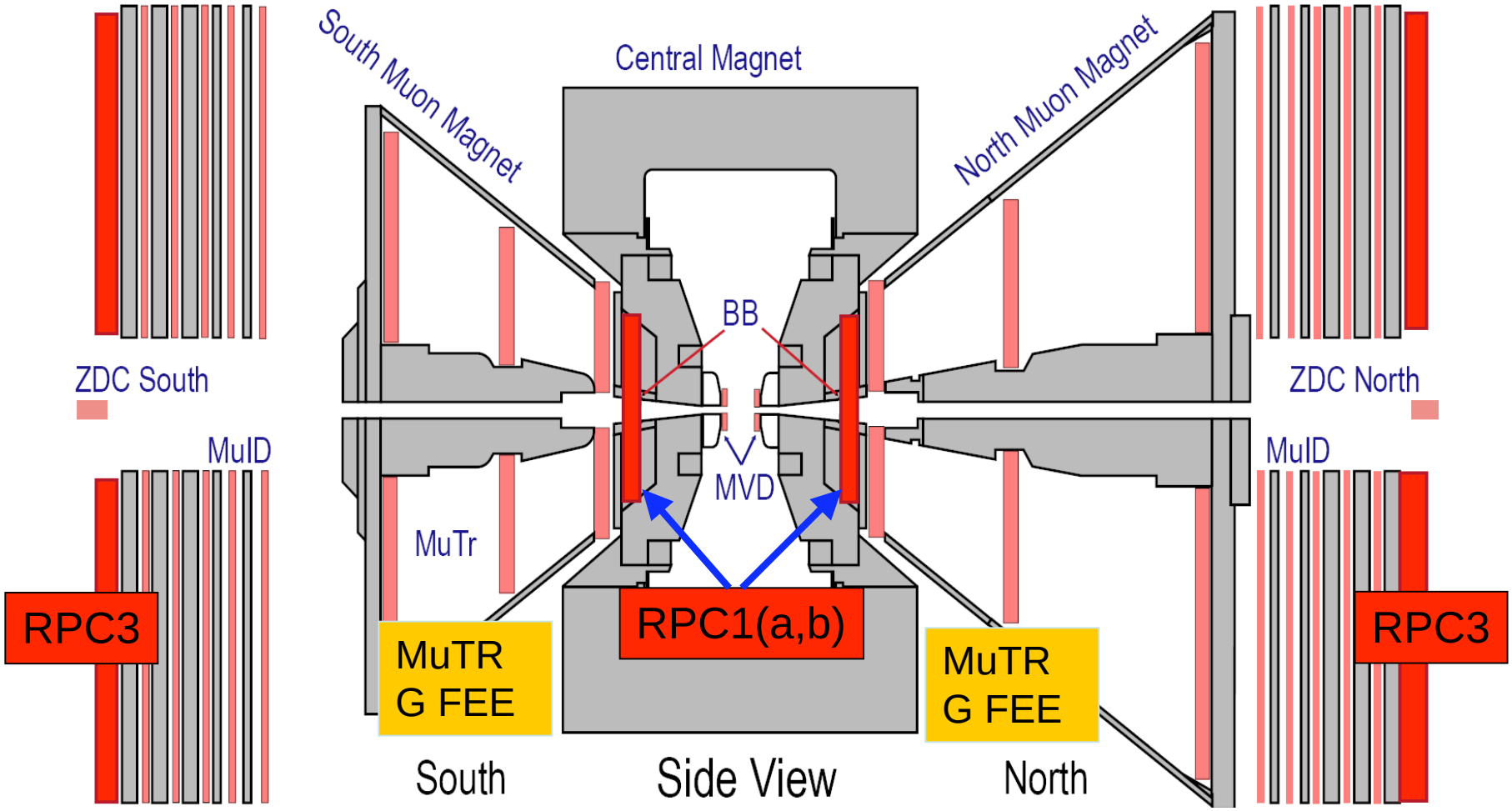
Current Muon System



Magnetic field lines with the outer Central Magnet coil energized

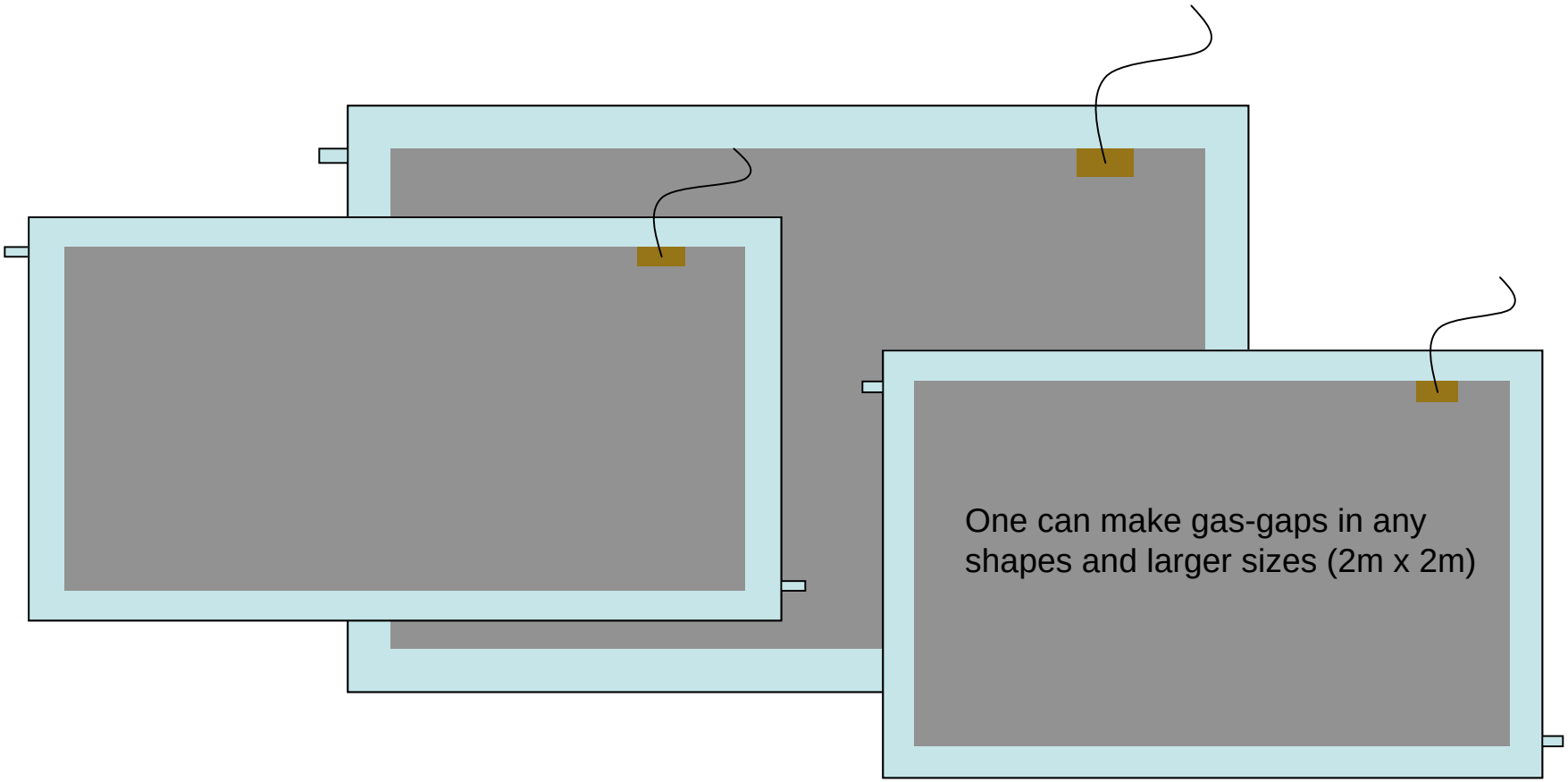
2.2 (2.4)

SCOPE OF THE MUON TRIGGER UPGRADE: MuTRG Frontend electronics upgrade + Resistive plate chambers (RPC)

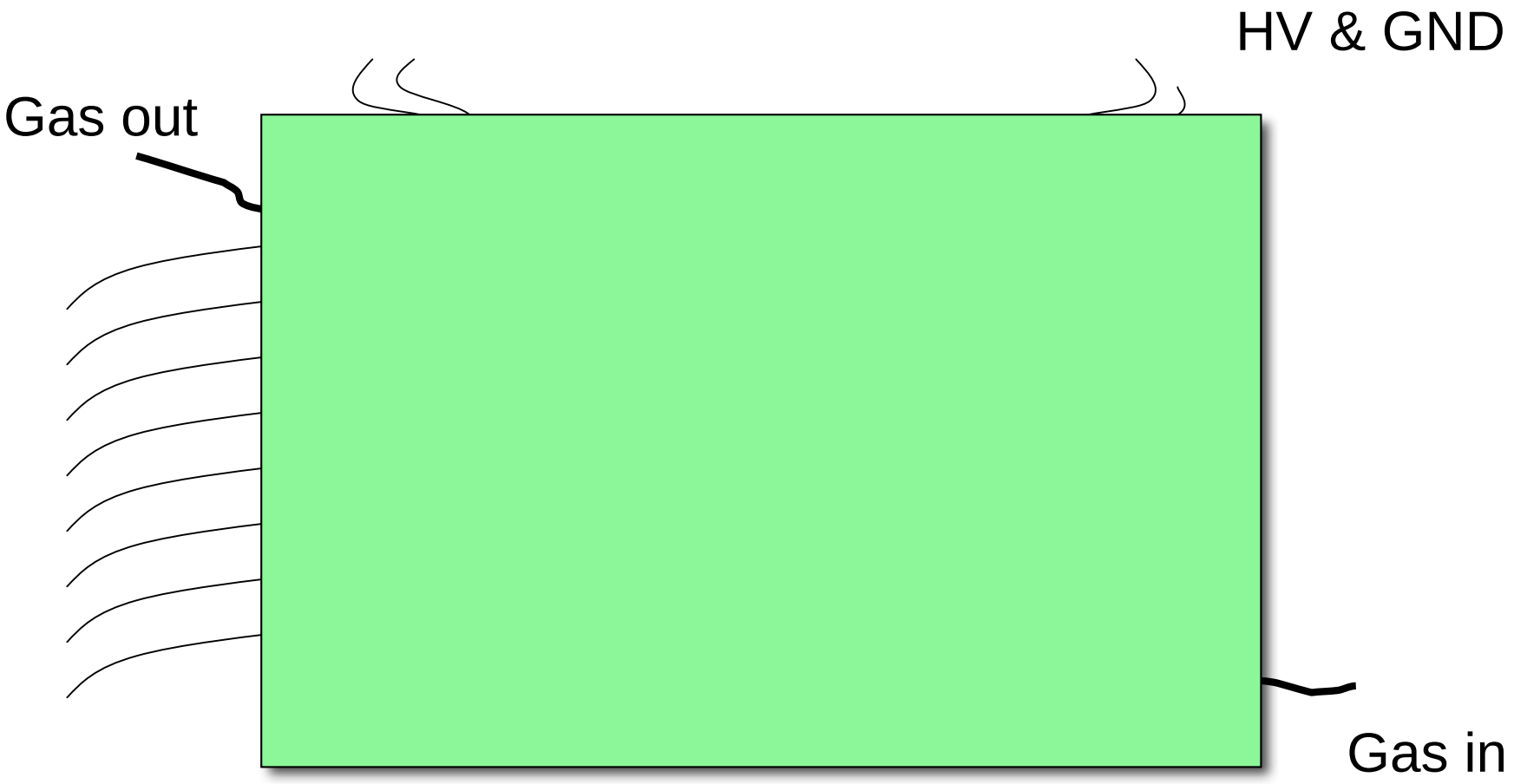


PRC Technology

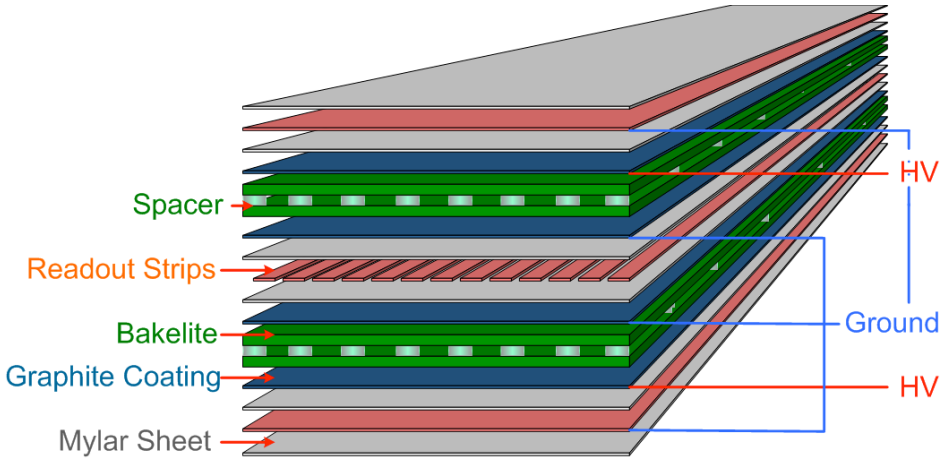
Making RPC Gas-Gaps



RPC Module Assembling



PHENIX Muon Trigger RPC



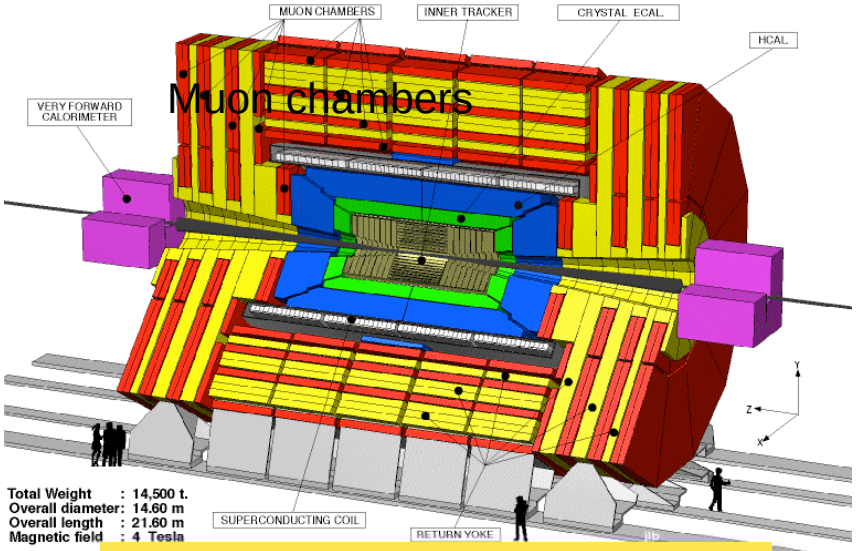
PHENIX RPC detector requirement

Efficiency	> 95%
Time resolution	≤ 3 ns
Average cluster size	≤ 2 strips
Rate capability	0.5 kHz/cm^2
Number of streamers	< 10 %

Characteristics of RPC

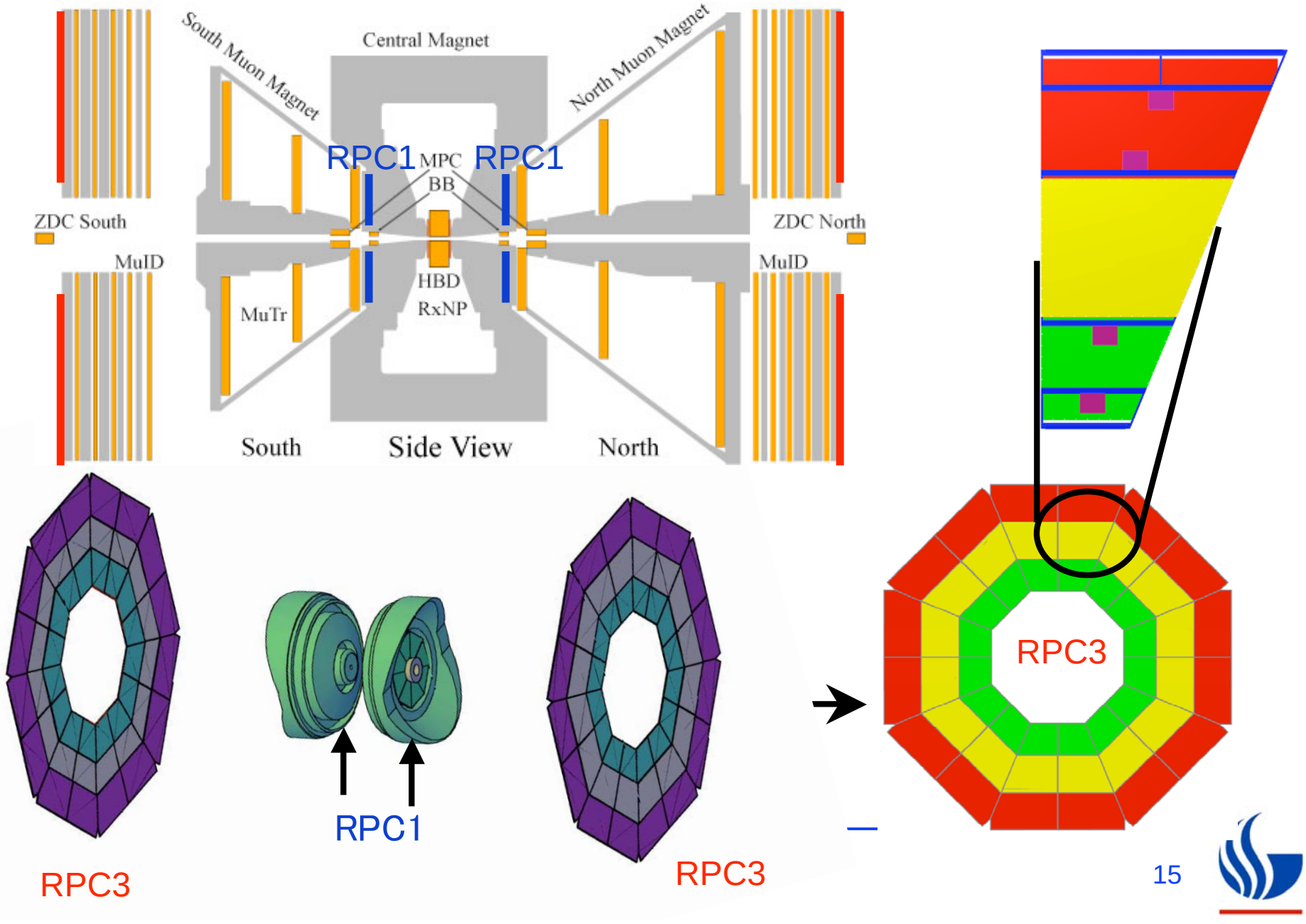
- Fast response
  - Suitable for the trigger device
- Good intrinsic time resolution: 1-2 ns
- Good spatial resolution: typically ~ cm
  - Determined by the read-out strip width and cluster size
- Low cost
- Typical gas mixture

  95% $C_2H_2F_4$ + 4.5% i-C_4H_{10} + 0.5% SF_6



PHENIX Picked RPC Technology Developed for CMS/LHC

RPC Modular design

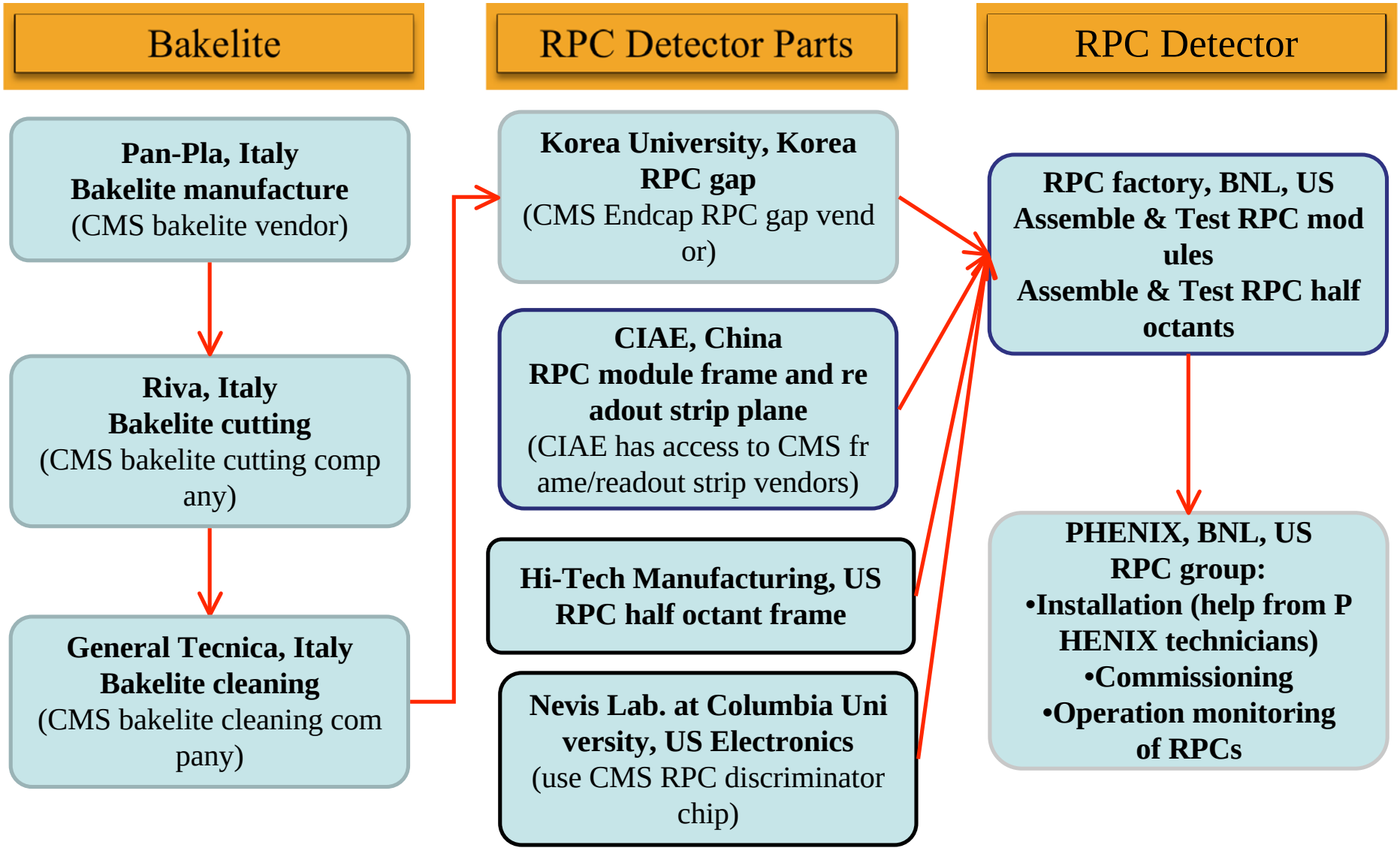


RPC Production

Flow of RPC Gaps and Parts for PHENIX

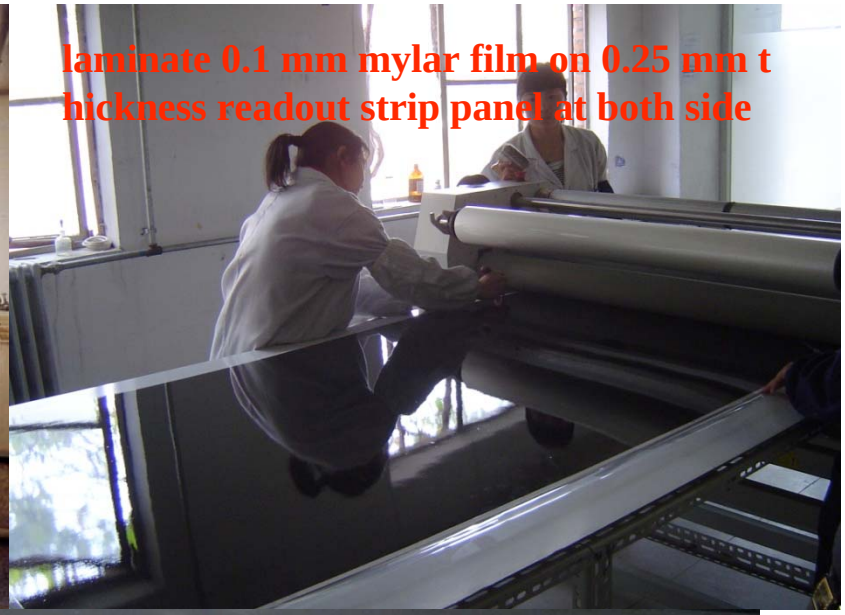
- **Bakelites are produced, cut, cleaned in Italy.**
- **Gas gaps are produced at Korea University in Korea.**
- **RPC module frames & readout strip planes are procured in China (CIAE).**
- **RPC half octant frames will be produced at Hi-Tech Manufacturing in US.**
- **Final assembly is done at BNL.**
- **Flow is exercised with prototype C and D.**

RPC Detector Production Assembly and Installation

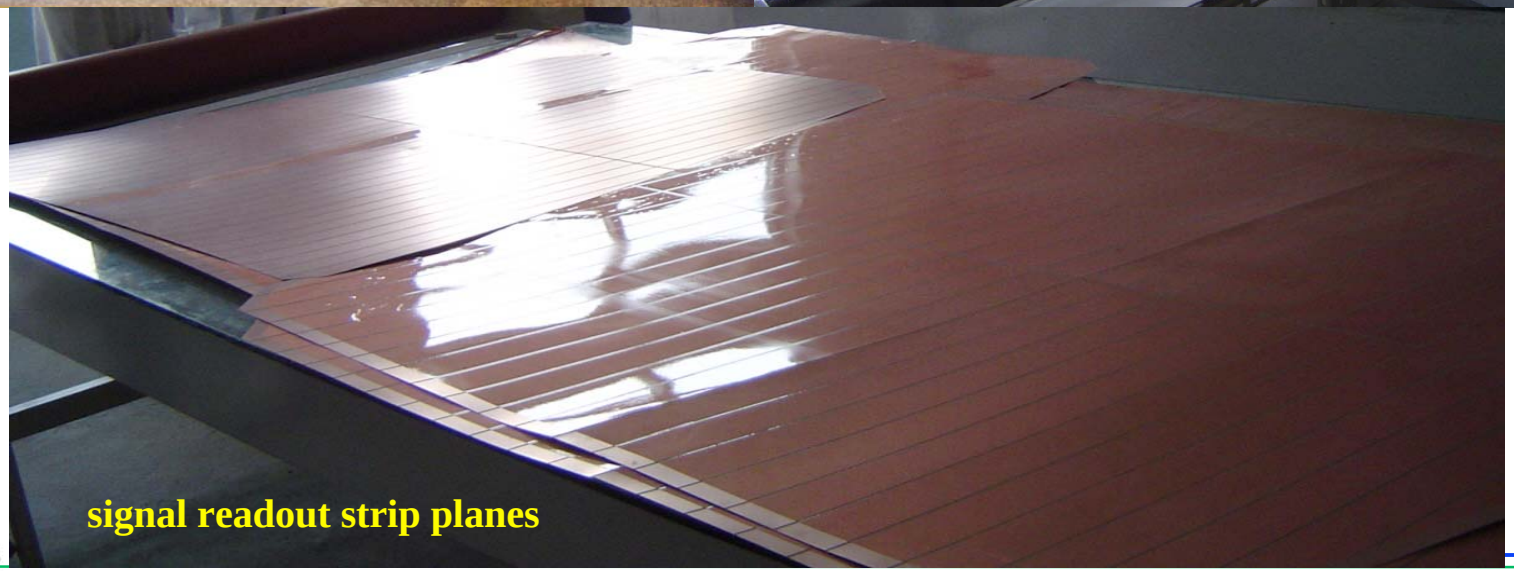


RPC Readout Strip Panel Production in China

Production site: Beijing Kedi Co.



laminate 0.1 mm mylar film on 0.25 mm t hickness readout strip panel at both side



signal readout strip planes

RPC Assembly and Test

RPC Detector Module Production at BNL

Prepare all RPC detector parts

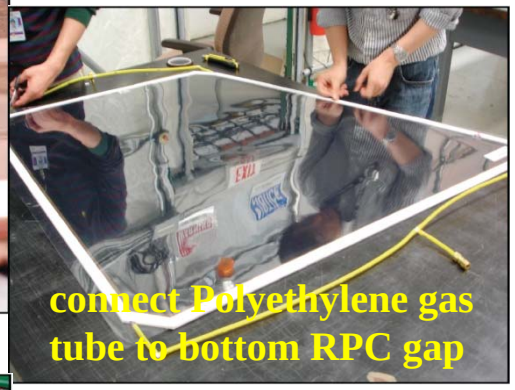
8 mil Mylar foil, 5 mil Cu foil
Readout strip plane with transition card
Polyethylene gas tube, Ground bus cable
CPE H.V cable, Kapton tape, Cu tape, etc.

RPC detector module assembly procedure

- Clean honeycomb panels and Al frames
- Attach Al frames to bottom honeycomb panel
- Lay down Mylar foil
- Lay down Cu foil
- Attach Mylar foil on H.V side at bottom RPC gap
- Connect Polyethylene gas tube to bottom RPC gap
- Place bottom RPC gap into detector module housing
- Connect CPE cable to H.V cable on bottom RPC gap


lay down Mylar foil


lay down Cu foil

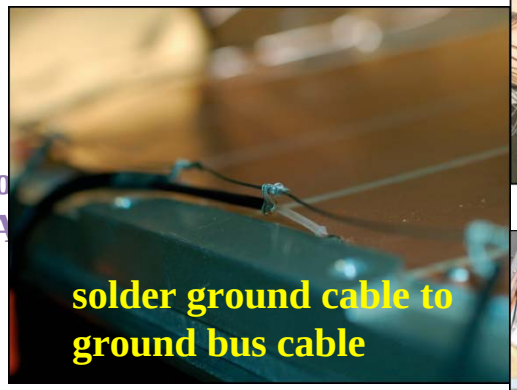

connect Polyethylene gas tube to bottom RPC gap

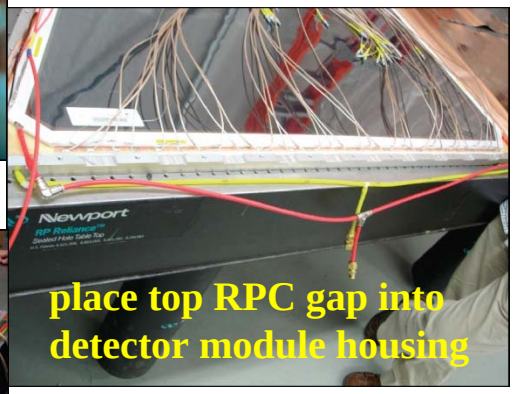

place bottom RPC gap into detector module housing

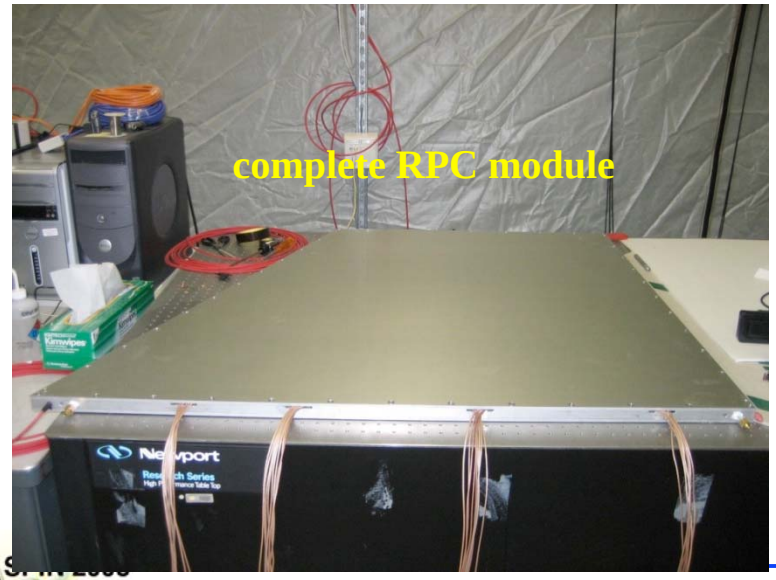

connect CPE cable to H.V cable on bottom RPC gap

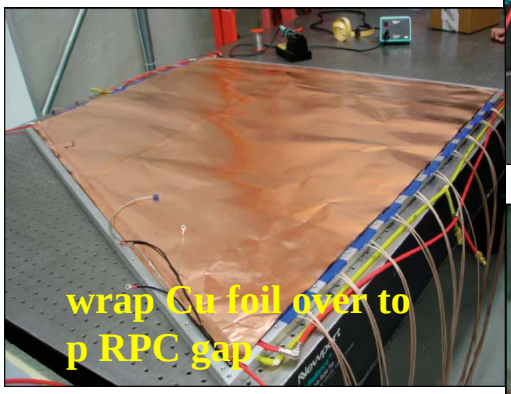
RPC Detector Module Production at BNL (continue)

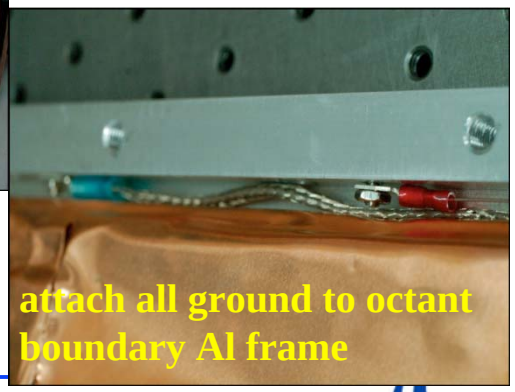
- Put readout strip plane on top of bottom RPC gap
- Solder ground cable to ground bus cable
- Attach Mylar foil on H.V side at top RPC gap
- Connect Polyethylene gas tube to top RPC gap
- Place top RPC gap into detector module housing
- Connect CPE cable to H.V cable on top RPC gap
- Wrap Cu foil over top RPC gap
- Attach all ground cables (from CPE H.V cables, gro und bus cables, and RPC gaps) to octant boundary A l frame
- Solder the other end of ground bus cable on Cu foil
- Lay down Mylar foil
- Put top honeycomb panel and close it with screws











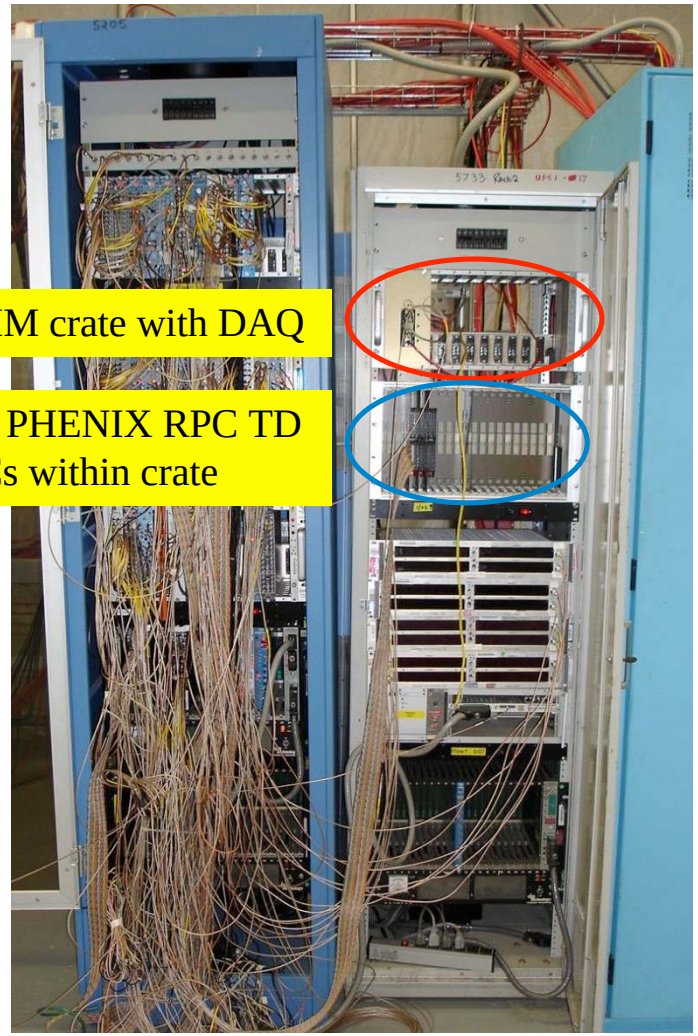
RPC Detector Module Test

cosmic ray trigger (10 scintillators readout both sides)

10 shelves for RPCs

cosmic ray trigger (12 scintillators readout both sides)

cosmic ray test stand at RPC factory



NIM crate with DAQ

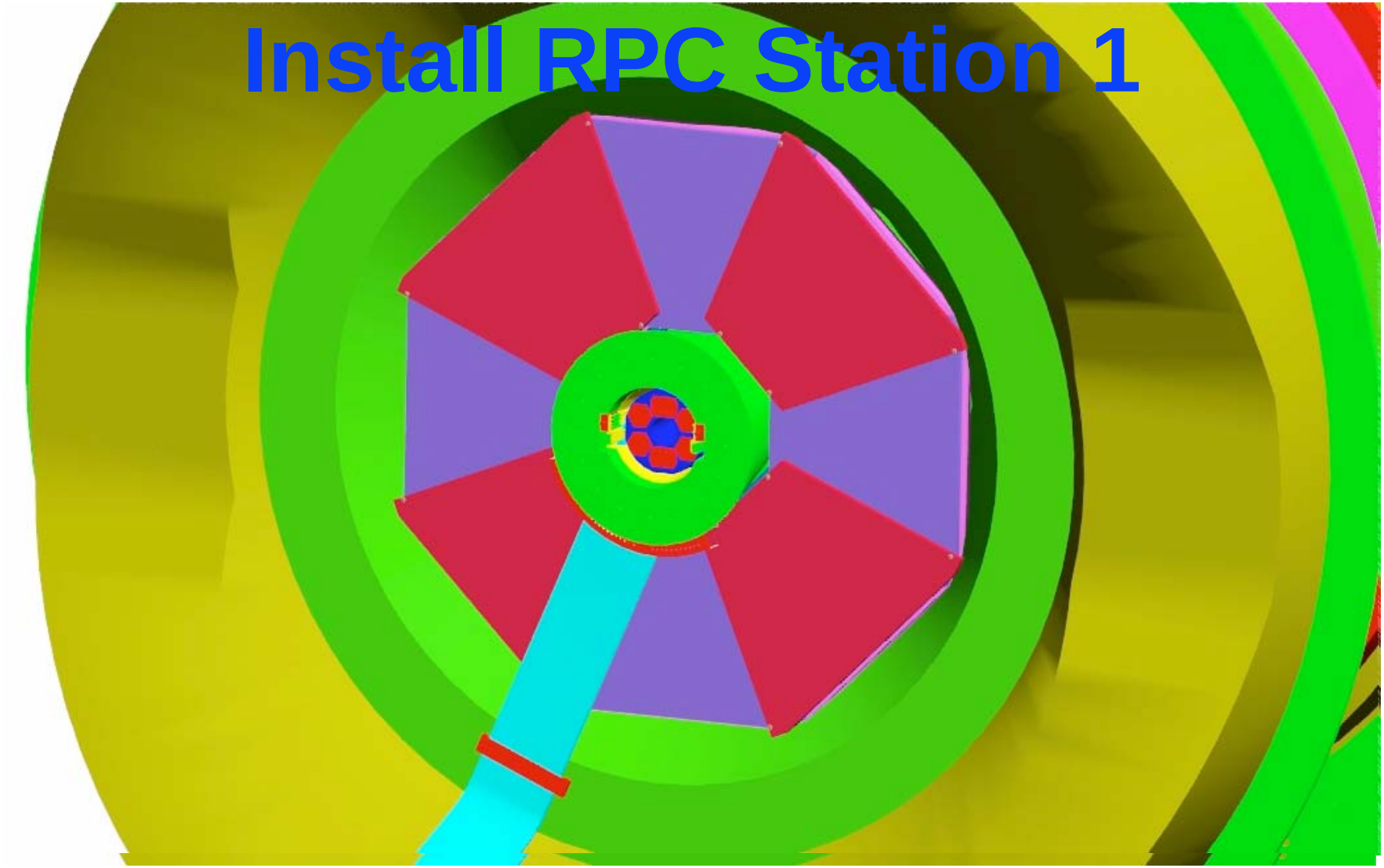
3 PHENIX RPC TDCs within crate

- We are measuring:

Noise rate, Total (2D) and strip efficiencies, Position and time resolutions, Cluster size

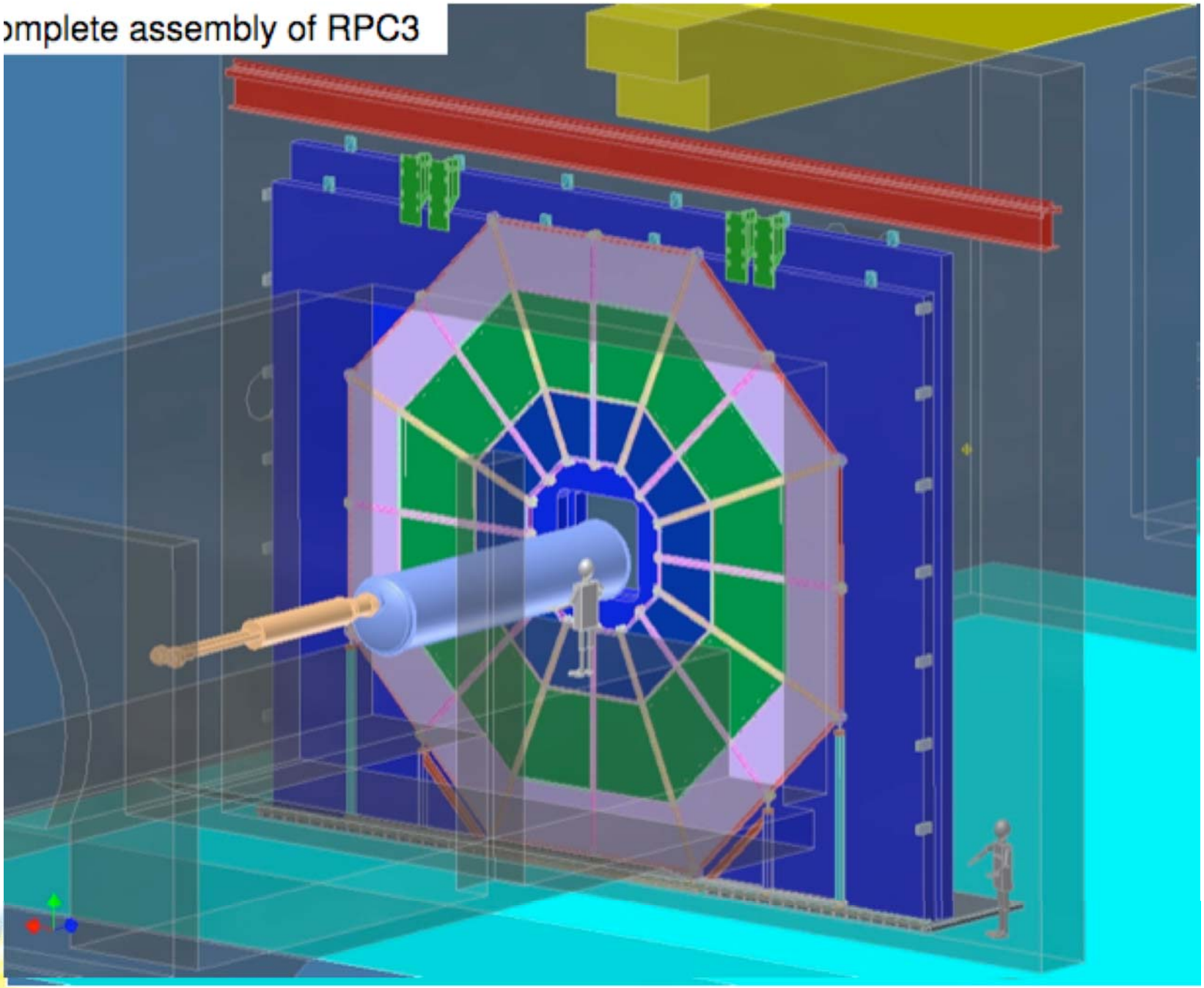
RPC Integration

Install RPC Station 1



The starting configuration before the installation of the new shielding
The [illegible] is supported by a steel aluminum ring bolted to the shielding

ɔmplete assembly of RPC3



Staged Installation Schedule

- Prototype (two half octants, in real size) will be installed during 2008 shutdown.
- PRC 3 North: During RHIC shutdown in 2009
- RPC 3 South: During RHIC shutdown in 2010
- RPC 1 N & S: During RHIC shutdown in 2011

Summary

1. Two half-octant prototype D's will be installed about one month from now.
2. RHIC will commission its 500 GeV p+p in Run-9.

Stay Tuned !!!

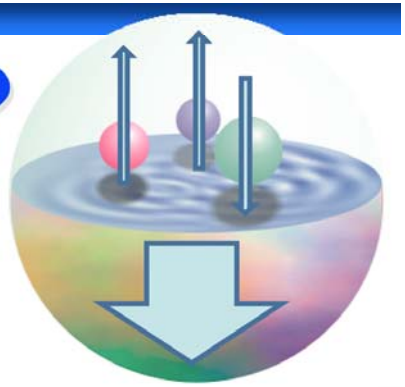
Picture was taken in July 2008

Participating Institutions
for the PHENIX Forward Muon Trigger Upgrade

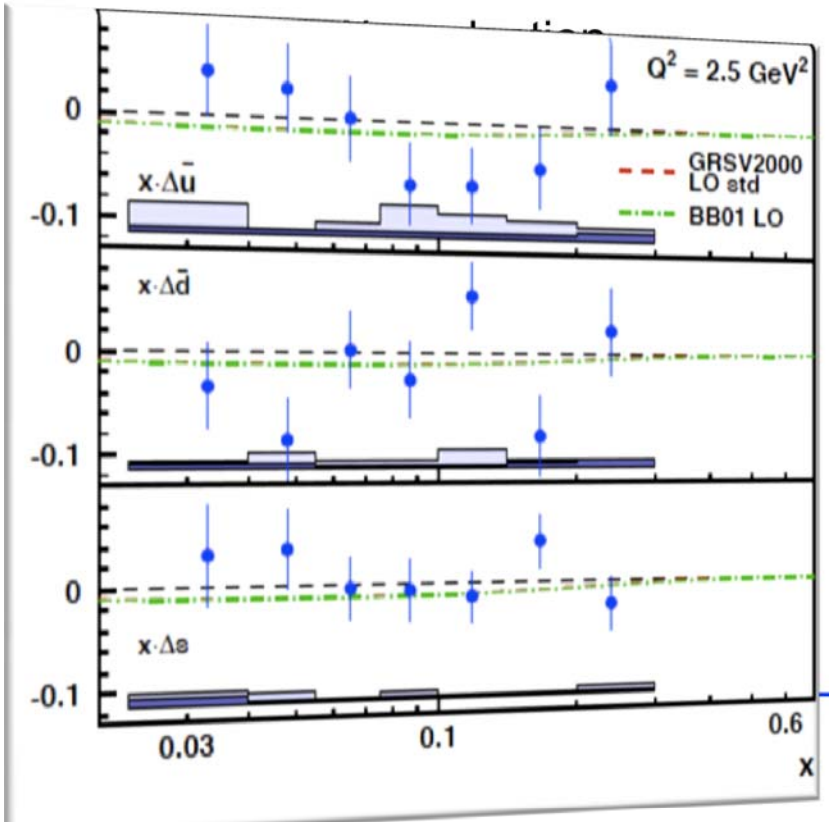
- Abilene Christian University
- Brookhaven National Laboratory
- University of California, Riverside
- China Institute of Atomic Energy
- University of Colorado
- Columbia University & Nevis Laboratory
- Georgia State University
- University of Illinois, Urbana
- Iowa State University
- KEK
- Korean University
- Kyoto University
- Los Alamos National Laboratory
- Muhlenberg College
- University of New Mexico
- Peking University
- RIKEN Brookhaven Research Center
- Riken Institute
- Rikkyo University

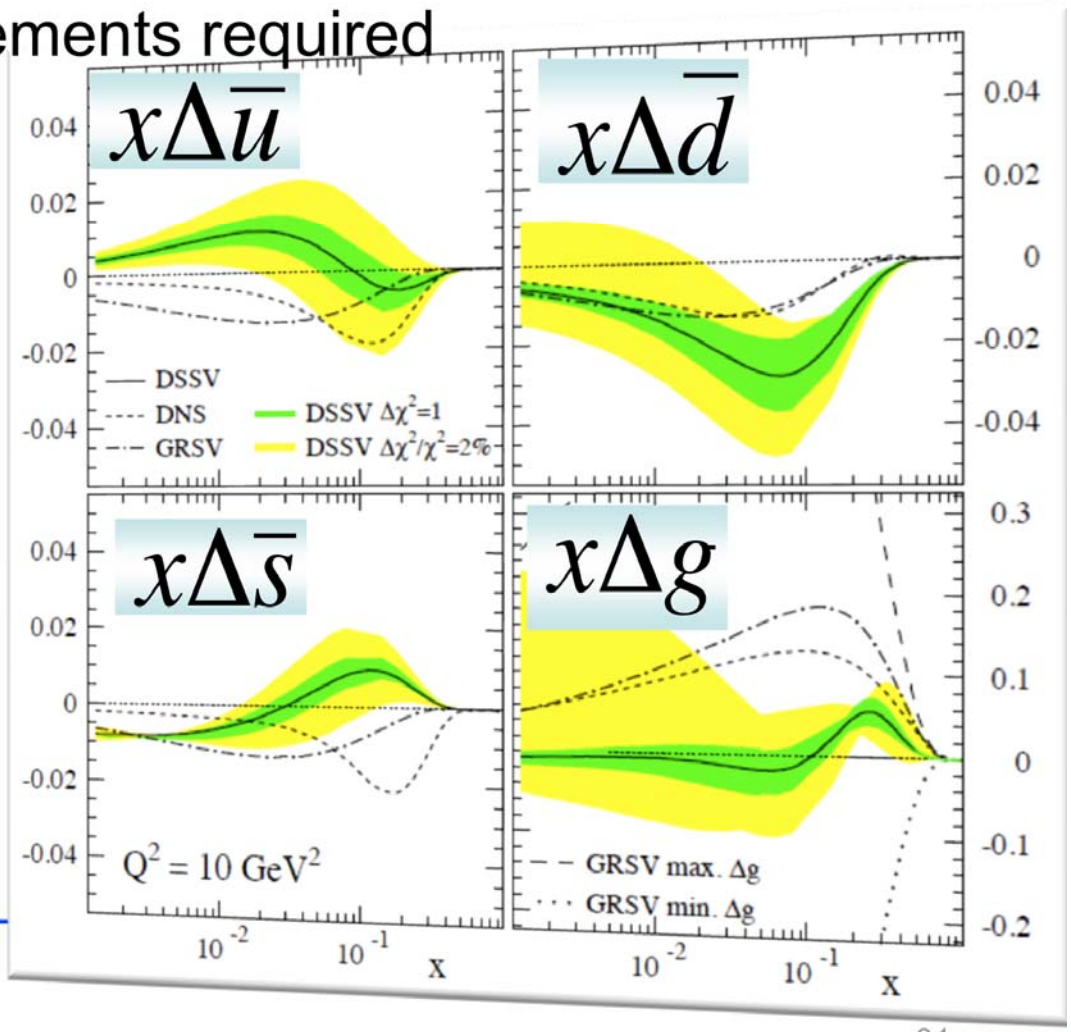
Backups

Are Sea Quarks Polarized?



- A fundamental question to further break down the quark spin contents $\Delta\Sigma \sim 0.25$
- Flavor sensitive measurements required
  - Semi-inclusive
  - Weak interaction





Trigger Rate and Rejection

Design Luminosity
$\sqrt{s}$ = 500 GeV σ=60mb
L = 1.6 x10^{32}/cm^2/s

Total X-sec rate＝9.6 MHz

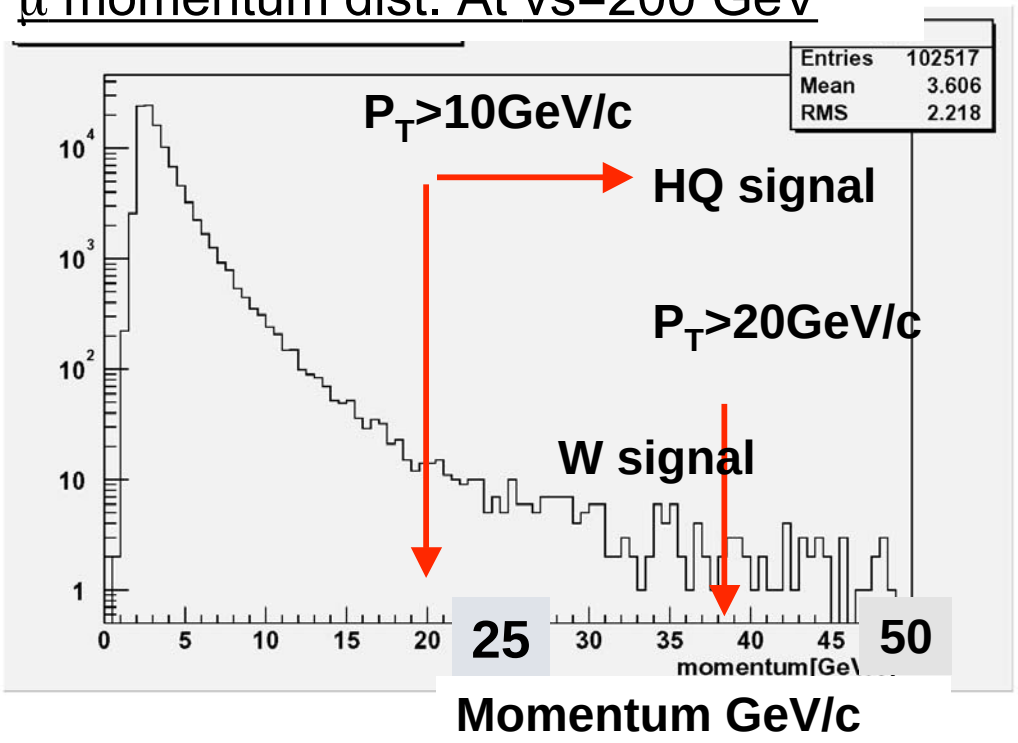
DAQ LIMIT
=1-2 kHz （for μ arm）

Required RF
10,000

BUT

MuID LL1
RF=200 ~ 500

μ momentum dist. At vs=200 GeV



Need Momentum Selectivity in the LVL-1 Trigger!

Abstract

The BNL PHENIX experiment is designed for studying matter at ultra high temperatures and densities with heavy ion collisions and the proton spin via polarized proton-proton collisions. A fast resistive plate chamber (RPC) based trigger system is being developed for the muon arms that allows measurement of the flavor structure of the quark polarization in the proton through observation of W-bosons in proton-proton collisions at sqrt(s) = 500 GeV. This talk will focus on RPC R&D, production of the RPC components, assembly of the RPC modules at BNL, and test results of prototypes. Challenges of RPC integration into PHENIX will also be presented.